Satisfactory Learning Opportunities for 'multi-sensory learning' with Educational Software Systems

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Abstract

A number of studies have concluded that one of the best approaches to accelerate the learning process is to apply a 'multi-sensory' learning approach in which learners are provided with as many different learning styles as possible, facilitating the flow of information to the learners' brains simultaneously and holistically. This process can be aided by the use of educational software. This paper attempts to identify an education software system that truly supports a 'multi-sensory' learning approach. Different multimedia/interactive features embedded within educational software can be designed to stimulate different learning styles. From a review of the literature, a number of multimedia/interactive features that stimulate learning styles have been identified in educational software systems. To adequately cover and facilitate the understanding of the roles of these multimedia/interactive features in stimulating learning styles, two architecture models of the human brain, namely the 'Split-Brain' and 'Multiple Intelligences' models, have been utilized in this paper. A survey based on a number of studies in educational software concluded that the Computer Based Training (CBT) Software System and the Mind Mapping (MM) System have been found to stand out above the others in their ability to design and apply a diverse range of multimedia/interactive features, thereby enabling learners to engage in a variety of learning styles. The survey also reveals that one or more multimedia/interactive features that were found to be applicable in one system were found to be not applicable in the other. Further investigation into those multimedia/interactive features that were found to be non applicable in either one or the other system, was conducted. It was found that these features play a significant role in stimulating certain learning styles and hence this paper concludes that neither CBT nor MM software systems have the capability to accommodate a truly 'multi-sensory' learning methodology.

Keywords

Multiple Intelligences, Split-Brain, Computer Based Training, Mind Mapping, Multi-sensory learning

1. INTRODUCTION

A number of studies have concluded that one of the best approaches to accelerate the learning process is to apply a 'multi-sensory' learning approach, in which learners are provided with as many different learning styles as possible, facilitating the flow of information to the learners' brains simultaneously and holistically. This approach is aided by the use of educational software (Chen & Chang 2000; Franco 2007; Good 2003; Kay 2001; McKenzie 2002).

This paper attempts to answer the question: Are there any educational software systems that satisfactory provide 'multi-sensory' learning opportunities? Data required to answer this question has been compiled from the exploration of 41 publications, retrieved from various sources.

Multimedia/interactive features built-in within most educational software systems can stimulate one or more learning styles, thereby providing learners with a heightened and more satisfying learning experience (Chen & Chang 2000; Franco 2007; Good 2003; Kay 2001; McKenzie 2002). From the 41 publications reviewed, all possible multimedia/interactive features that can be designed and applied to educational software systems have been identified.

To adequately cover and facilitate the understanding of the roles of these multimedia/interactive features in stimulating learning styles, two architecture models of the human brain have been selected:

- The first model is: 'Split-Brain' theory, devised by Sperry (1982) in which he uncovered the different roles of each side of the human brain and where he concluded that there are two major learning styles, each corresponding to one hemisphere of the brain.
- The second model is: 'Multiple Intelligences' by Gardner (1983) in which he proposed a set of seven different learning styles, processed through different areas of the brain.

Two education software systems, namely: CBT and MM software systems have been found to be able to be programmed to implement a vast variety of multimedia/interactive features. However, one or more of the available multimedia/interactive features that were found capable of being programmed into one system were found to be not capable in the other.

Accordingly, multimedia/interactive features can be categorised into three groups:

Group 01: Multimedia/interactive features that can be implemented in both CBT and MM software packages;
Group 02: Multimedia/interactive features that can be implemented only in CBT software packages; and
Group 03: Multimedia/interactive features that can be implemented only in MM software packages.

Further investigation into these multimedia/interactive features that were found to be non applicable in one or the other system (i.e. Groups 02 and 03) was conducted. It was found that these features play a significant role in stimulating certain learning styles and hence this paper concludes that neither CBT nor MM software systems have the capability to accommodate a truly ‘multi-sensory’ learning methodology.

The rest of this paper is organized as follows: In Section 2, we will explore the background theories behind the two sets of learning styles introduced by Sperry (1982) and Gardner (1983) in more detail. Section 3 is dedicated to the discussion of CBT and MM software systems and their relationships with the various learning styles. Numerical data required to establish the relationship between learning styles and multimedia/interactive features employed within CBT and MM software systems in detail was extracted from 41 publications. The presentation of this data concludes Section 3. Finally in Section 4, the analysis on the findings in Section 3, as well as the conclusions and limitations of this paper are presented.

2. BACKGROUND ON LEARNING STYLES

Over the last 30 years, researchers have unearthed a treasure trove of knowledge concerning how the human mind works, how the human brain is structured and functions, and how people learn (Levine 2001, as cited in Kay 2001; Smith 2004). Discoveries in human brain anatomy and their implications for areas such as learning, have gained much momentum, with the US Congress designating the 1990’s as the “Decade of the Brain,” (Bush 1990). During this period a number of models of human brain architecture were proposed to aid the explorations and interpretations of the different aspects of the brain (Smith 2004). Unlike a vast majority of the literature, which utilized one of the human brain architecture learning model to explain the role of intelligence and learning styles and to present their respective arguments, this paper utilizes two learning models, namely ‘Split-Brain’ (Sperry 1982) and ‘Multiple Intelligences’ (Gardner 1983) models.

Sperry’s Split-Brain Theory

Sperry’s (1982) research established that the brain is divided into two major parts - the right and left brain, and that each hemisphere of the brain specializes in its own style of thinking and has different capabilities. Accordingly, people can be categorized as being either left brain dominant or right brain dominant.

Table 1: Left Brain and Right Brain functioning.

General category	LEFT Hemisphere	RIGHT Hemisphere
linguistic/visual	words and language	symbols and images
	speaking	visual-pictorial
logic	uses logic	uses feeling
	math & science	philosophy, religion & music
orientation	detail oriented	"big picture" oriented
	linear	Nonlinear
	sequential	Simultaneous
perception	order/pattern perception	spatial perception
	pattern user	pattern seeker
	black and white	Colour
way of thinking	reality based	fantasy based
	propositional	Imaginative
	apply rule	apply creativity
knowing	knowing	believing
	knows object name	knows object function
Action	forms strategies	presents possibilities
	practical	Impetuous
	safe	risk taking
	present and past	present and future
Neurotransmitters	higher levels of norepinephrine	higher levels of dopamine
Grey/White Matter ratio	more white-matter (longer axons)	more grey-matter (cell bodies)
Shared	Sensations on both side of face, sound perceived by both ears, pain, hunger	

*Note: Information within is extracted from the Courier Mail (2008 February), the Daily Telegraph (2007 October), Eden (2008), Morris (2008)***,** *OEDC (2009), Pitek (1998), Sankaran (2009) and Sperry (1982).*

The Left Brain: The left brain is better with verbal, logical, and analytical thinking. It excels in naming and categorizing things, symbolic abstraction, speech, reading, writing, and arithmetic. It is associated with thinking and learning in a logical sequence, or stepwise fashion. (Mann 2005) Left brain dominant people are good at focusing on individual components, attending to details and solving problems in a methodical, serial-ordered manner. They learn best by exploring things sequentially. They see the trees instead of the forest (Critcher & Ferguson 2010).

The Right Brain: The right brain processes information differently to the left brain. It has been associated with the realm of creativity. It functions best in a non-verbal way, excelling in visual, spatial, perceptual and intuitive information. It flourishes in dealing with complexity, ambiguity and paradox. For right brain dominant people, processing happens very quickly and holistically, and the style of processing is non-linear and non-sequential. At times, they experience difficulty putting concepts into words because of their ability to process complex and non-verbal information quickly (Mann 2005; Pitek 1998). They are not concerned with things falling into patterns because of prescribed rules. They tend to emphasize the importance of the whole and quickly seek to determine the spatial relationships of all the parts as they relate to the whole. They see the forest instead of the trees. They are able to see the big picture (Critcher & Ferguson 2010).

Since the inception of split-brain theory by Sperry (1982), there have been a number of discoveries confirming that each side of the brain provides specific ways of interpreting information and reacting to situations. A summary of these discoveries has been compiled and presented in Table 1.

Gardner’s Multiple Intelligences (MI) Theory:

The theory of multiple intelligences was introduced by Gardner (1983) to more accurately define the concept of human intelligence. It quickly became established as a classical model to understand and teach many aspects of human intelligence, learning styles, as well as explain personality and behaviour, both in education and in industry. Gardner initially developed his ideas and theories as a contribution to psychology; however Gardner's theory was soon embraced by education, teaching and training communities, a sign that he had created a classic reference work and learning model (Chapman 2003).

Gardner (1983) originally proposed a list of seven intelligences. Briefly, the first two, which include linguistic and logical-mathematical intelligence, have been typically valued in schools; the next three, which include musical and bodily-kinesthetic intelligence, are usually associated with the arts. The final two, which include interpersonal and intrapersonal intelligence, are what Howard Gardner called 'personal intelligences.' The following are descriptions of Gardner’s multiple intelligences, compiled from Gardner (1983), Smith (2004) and Richard (2009).

Intelligences that have been typically valued in schools:

1. Linguistic intelligence: involves sensitivity to spoken and written language, the ability to learn languages, retention, interpretation and explanation of ideas and information via language and the capacity to use language to accomplish certain goals. This intelligence includes the ability to effectively use language to express oneself rhetorically or poetically; and use language as a means to remember information.

2. Logical-mathematical intelligence: consists of the capacity to analyze problems logically, carry out mathematical operations, understand the relationship between cause and effect towards a tangible outcome or result, and investigate issues scientifically. It entails the ability to detect patterns, reason deductively and think logically. This intelligence is most often associated with scientific and mathematical thinking.

Intelligences usually associated with the arts:

3. Spatial/Visual intelligence: involves the potential to recognize and use the patterns of wide space and more confined areas. It consists in the ability to interpret and create visual images, imagine and express concepts pictorially, and understand relationships between images and meanings; as well as between space and objects.

4. Bodily-Kinesthetic intelligence: entails having the innate ability to use one's whole body, or parts of the body, to solve problems. It is the ability to use mental abilities to coordinate bodily movements. This type of intelligence is associated with manual dexterity, physical agility and balance; as well as eye and body coordination.

5. Musical intelligence: involves skills in the performance, composition, and appreciation of musical patterns and sound. It encompasses the capacity to recognize and compose musical pitches, tones, and rhythms, as well as to understand the relationship between sound and feeling.

Intelligences usually associated with individual personality:

6. Interpersonal intelligence: is concerned with the capacity to understand the intentions, motivations and desires of other people. It allows people to work effectively with others. It also encompasses the ability to relate to others; interpret behaviour and communications; and understand the relationships between people and their situations.

7. Intrapersonal intelligence (self-reflection, self-discovery): entails the capacity to understand oneself, to appreciate one's feelings, fears and motivations. It involves having an effective working psychological model of ourselves, and being able to use such information to regulate our lives. It is also related to personal cognizance and personal objectivity - the capability to understand oneself, one's relationship to others and the world; and one's own need for, and reaction to change.

When the theory of multiple intelligences was conceptualized, Gardner (1983) added:

> While each of these intelligences has its own distinct characteristics, the whole intelligence apparatus act in consort and are not mutually exclusive. They also overlap one another. Everyone has all the intelligences. The strength of a particular intelligence varies from person to another, and one can strengthen an intelligence type.

Since Gardner (1983) devised these seven intelligences, there has been a great deal of discussion as to other possible candidates for inclusion. Subsequent research and reflection by Gardner and his colleagues have looked into three particular possibilities: a naturalist intelligence, a spiritual intelligence and an existential intelligence. Gardner (1999, as cited in Smith 2004) concluded that the first of these “merits addition to the list of the original seven intelligences.” However, these final additions to Gardner’s Multiple Intelligences model have been omitted in this paper as they are not applicable to the subject matter being discussed.

'Multi-sensory Learning' Approach:

Although Sperry (1982) and Gardner (1983) proposed their corresponding sets of learning styles independently, there are some commonalities within their arguments. One of them is that each area of the brain is associated with greater efficiency in learning and solving specific tasks, and that the most effective problem-solving and learning strategy is to take advantage of the best that each and every area of the brain can offer by allowing all areas of the brain to engage simultaneously (Schmeck 1988, as cited in Liu & Ginthe 1999). In other words, if the whole brain is engaged in learning, the learning process is dramatically accelerated (Lozanov 1978; Good 2003).

Gardner (1982) referred to this learning approach as 'multiple chance theory of education.' Depending on the circumstances, others referred to this approach of learning as 'whole brain learning', 'whole brain thinking', 'multi-channels learning,' 'multi-sensory learning,' 'global learning' or 'holistic learning,' and this approach is recommended by a number of experts from both the academic (e.g. Carlson-Pickering 1999a; Gardner 1982; Clayton & Kimbrell 2007; Goldberg 2004; Mills 2001) and commercial (e.g. Chapman 2003; Morris 2008; 2004; Rose 1985) worlds, as well as other interest groups. (e.g. OEDC 2009; Sankaran 2009; Sicinski 2008).

'Multi-sensory Learning' approach is aided by the use of educational software as strong relationships exist between multimedia/interactive features embedded within educational software and learning styles (Chen & Chang 2000). According to Franco (2003), this relationship is "far too strong to go completely unnoticed." McKenzie (2002) agrees, stating that "… there are surefire types of instructional technology that accommodate specific learning styles." Sword (2000) also concurs, adding: "each technological medium corresponds to one or more human intelligence path ways or learning styles which act as passage for delivering information to the human brain."

3. CBT AND MM SOFTWARE SYSTEMS AND LEARNING THEORIES

Perception of learning styles has altered radically in the past 25 years (Microsoft Learning Suite 2010). New approaches, such as the whole brain learning methodology described in Section 2, have highlighted new ways of advancing creativity and understanding across most education software technologies (Chen & Chang 2000).

Data acquired in this paper is extracted from the exploration of 41 publications, retrieved from a cross-section of available sources. The vast majority of the literature describe the relationship between learning styles and multimedia/interactive features such as text, images, color, audio and video as commonly employed by a range of software applications, including software applications such as word processing, spreadsheets etc. Although it was noted that software applications such as word processing, spreadsheets etc. were identified as having the ability to stimulate certain learning styles (McKenzie 2002), the level of stimulation was found to be minimal. Presentation software such as Microsoft PowerPoint, which has been designed for use as an educational tool, in terms of its ability to stimulate learning styles, cannot be considered to be a highly valuable instrument for learning (Good 2003). The study by Kurtus (2006) concurs with this assessment and recommends that one should only consider using such presentation software at the "basic" or "simplest" level, largely due to the 'linear' nature of its presentation format. He (2006) suggested that for developing higher level of education packages, CBT software packages should be utilized as they are specifically designed for that purpose.

Computer Based Training (CBT) Software Systems

CBT, also commonly referred to as 'computer assisted instruction', 'computer assisted learning', 'distance learning', and 'technology based training' (Henke 2001) or eLearning (Education Resources 2006; Franco 2007) refers to any course of instruction whose primary means of delivery is via a computer software system. CBT has existed for over four decades, but was not widely used until the advent of the personal computer (Mills 2001). CBT software supports multiple learning styles (Microsoft Learning Suite 2010) and is a fast-growing field (Henke 2001). CBT software is embedded with rich multimedia/interactive features that can help to create a rich and engaging learning environment that enables students to unlock their talents and realize their full potential (McKenzie 2002). CBT can deliver many kinds of courses in many companies, institutions and international organizations around the world (Good 2003).

Schaller (2005) recommended that, in designing a CBT software system the programmer should create a system that provides an engaging environment and effective experience for a wide variety of learners. To create a system with such capability, the designer should strive to achieve an understanding of individual differences in learning styles in order to provide valuable insights into the specific elements required.

Mind Mapping (MM) Software Systems

When Tony Buzan initially popularized the idea of Mind Mapping in 1974, he delineated 'accelerated learning' to be one of the main advantages of utilizing this system (Buzan 1993). Users, particularly visual spatial learners, can use Mind Mapping as an illustrative tool to assist them in managing thoughts, directing learning and making relational connections (Strauss 2006). The visual spatial learning style is associated with right brain activities under Sperry's Split Brain theory paradigm (1982) and visual intelligence under Gardner's Multiple Intelligences Theory paradigm (1983). A Mind Map is a construct of a series of visual images or key words that, in its totality, form a larger visual image (Carlson-Pickering 1999a). Physically, a mind map is a visual diagram with lines and nodes representing ideas and relationships between them. The core idea sits in the middle, with related topics branching out from it. The coloured keywords, images or symbols representing ideas are further broken down and extended until the page looks like an impressionist painting of a spider colony (Codswallop 2007).

Relationship between Learning Styles and CBT and MM Software Systems

Franco (2007), Chen & Chang (2000) and McKenzie (2002) have suggested that the best way of determining the strengths of an educational software application is to conduct an inventory of the multimedia/interactive features utilized in the software and then to analyze the degree of simulation they have upon each intelligence or learning style as described in Section 2. In order to identify an educational software system that truly supports a 'multi-sensory learning' approach, the main aim of this paper, 41 publications have been investigated. The data presented in Figure 1 and Table 2 represents a summary representation of this investigation. Figure 1 presents a bird's eye view of an inventory of the multimedia/interactive features utilized in the educational software systems and the applicability of these features in CBT and MM software systems.

From Figure 1 we can conclude that:

1. both CBT and MM software systems can be designed and implemented with a large number of these multimedia/interactive features, but not with all of the features; and
2. one or more multimedia/interactive features that can be implemented in CBT software packages cannot be implemented in MM, and vice versa.

Accordingly, multimedia/interactive features are categorised into three groups:

Group 01: Multimedia/interactive features that can be implemented in both CBT and MM software systems;
Group 02: Multimedia/ interactive features that can be implemented only in CBT software systems; and
Group 03: Multimedia/interactive features that can be implemented only in MM software systems.

Numerically, Figure 1 can be summarized as follows:

- There are 17 possible multimedia/interactive features that can be designed and implemented in educational software systems;
- 14 (or a vast majority) of these multimedia/interactive features can be implemented in both CBT and MM software packages. This group is referred to as Group 01.
- Out of the remaining three multimedia/interactive features, two were found to be capable of being implemented in CBT, but not in MM systems. This group includes the ability to (1) allow the user to learn at his or her own pace; and (2) provide the user with an interactive practice session. These are referred to as Group 02.
- The remaining feature (Group 03) is found to be capable of being implemented in MM, but not CBT. This group includes the 'zoom in/out' capability. In zoom-out mode, users have the opportunity to examine all the learning materials in a single bird's eye view. From zoom-out mode, users can then navigate and zoom into any particular section and learn the material in detail.
- The combination of CBT and MM software system covers all 17 possible multimedia/interactive features.

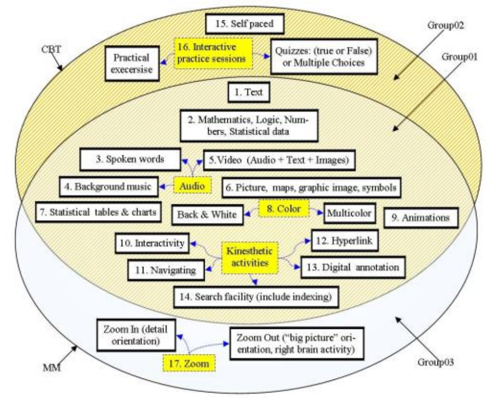

Figure 1: Multimedia and Interactive features applicable in CBT and MM

Table 2 illustrates the relationship between the multimedia/interactive features applicable in educational software systems and the learning styles proposed by Sperry (1982) and Gardner (1983) as described earlier. Note that the numbers specified at the intersections between multimedia/interactive features and corresponding learning styles, represent the number of publications that have been found to agree with the assertion that there is a relationship between each particular multimedia/interactive feature and the corresponding learning styles. For example number '22' appearing at the intersection between 'Text' and 'Linguistic', refers to the 22 publications that have been found to be in agreement with the idea that there is a relationship between the multimedia/interactive features 'Text' and 'Linguistic' learning styles.

From Table 2, we can observe that:

1. in some multimedia/interactive features such as 'text' or 'spoken words', a relationship exists between the particular multimedia/interactive features and those learning styles derived from either of the brain architecture models; and
2. in others, a relationship exists between the particular multimedia/interactive features and certain learning styles derived from only one of the brain architecture models, but not from both.

For example, it was found that in the case of multimedia/interactive features such as 'Animations' or 'Self pace', a relationship exists between the particular multimedia/interactive features and learning styles derived from the 'Multiple intelligences' model but not from 'Split brain' model.

On the other hand, in the case of multimedia/interactive features such as 'Zoom', it was found that a relationship exists between the particular multimedia/interactive features and learning styles derived from the 'Split brain' model, but not from 'Multiple intelligences' model.

This helps to explain the need to utilize the two brain architecture models in this paper.

Table 2: Relationship between multimedia/interactive features applicable in educational software programs and learning styles

			The Two Brain Models								
			Multiple Intelligences Theory							Split Brain Theory	
			Linguistic	Logical-mathematical	Spatial/Visual	Bodily/Kinesthetic	Musical / Rhythm	Interpersonal	Intrapersonal	Left hemisphere	Right hemisphere
Multimedia/Interactive features applicable in Educational Software	1. Text		22							15	
	2. Mathematics, Logic, Statistical			16	1					11	
	Audio	3. Spoken words	13							8	
		4. Background music					9				8
	5. Video (Audio, Text, Images)		6		10		2			3	3
	6. Picture, Maps, Image, Symbols			2	15						17
	7. Statistical tables and charts			3	14						5
	8. Color	black and white			5					1	4
		Multi-color									
	9. Animations				6	2					
	Kinesthetic activities	10. Interactivity			1	4			1		
		11. Navigating within			2	3			1		1
		12. Hyperlink				4			1		
		13. Digital annotation	1			4					
		14. Search facility	1		1	3					
	15. Self Pace		1			2			10		
	16. Interactive Practice Sessions		2	1	1	3			5	1	
	17. Zoom	Zoom-in (detail)								8	
		Zoom-Out (big picture)									16

4. ANALYSIS, CONCLUSION AND LIMITATIONS

One of the findings in Section 2 was that in learning, one should not ignore the importance of applying a 'multi-sensory learning' methodology in order to provide learners with the maximum opportunity to engage with all their learning styles.

Given that:

- both CBT and MM software were found to be able to design and implement applications using a diverse variety of multimedia/interactive features that facilitate and enhance the flow of information to the user's brain simultaneously and holistically,

and that:

- one or more multimedia/interactive features present in one system were found to be absent in the other,

the question that arises then is: Do CBT or MM software systems provide satisfactory learning opportunities for 'multi-sensory learning' methodology?

The answer to this question can be ascertained through a detailed examination and assessment of the magnitude of importance of those multimedia/interactive features that were present in CBT, but absent in MM, and vice versa.

Multimedia/interactive features applicable in CBT, but not applicable in MM:

Self Pace: Intrapersonal intelligence-dominant people enjoy being left alone to solve their problems (Armstrong 1994). They get more out of being left alone when learning (Shiratuddin & Landoni 2000) and the self-paced CBT program therefore poses an excellent learning tool for this type of individual (Carlson-Pickering 1999a). The ability to allow learners to learn at their own pace, plan their own learning activities, monitor their progress and evaluate their own learning outcomes, is one of the most crucial advantages of CBT-style programs. CBT grants the learner independence and autonomy, as well as control over all aspects of their learning experience/process (Franco 2003). Versatile technologies, especially those that include the capacity to allow users to learn at their own pace and in their own time, such as those embedded within CBT, fit the multiple intelligences approach to education. The technological ability to allow learners to study at their own pace is referred to, in CBT, as 'personalized education' (Gardner 1997, as cited in Chen & Chang 2000).

Interactive Practice Session: Good (2003) delineated computer-delivered quizzes and practice sessions as one of the most effective activities that can be adopted in CBT, and argues that it favors linguistic and bodily-kinesthetic dominant types of learners. However in an attempt to explain intrapersonal intelligence, Shiratuddin & Landoni (2000) delineated, amongst other things, the provision of "drill and practice programs" as examples of activities that cater for intrapersonal intelligence. Rose (1992, as cited in Laughlin 1999) argued that one of the techniques used to accelerate the learning process is to provide practice sessions as soon as the material has been studied, stating that hands-on practical experience stimulates students' kinesthetic intelligence. McKenzie (2002) suggested that providing practice sessions post study should be integrated into instructional technology so thoroughly that they become a vital piece in the learning process, enabling students to move from theory to practice more easily.

Multimedia/interactive features applicable in MM, but not applicable in CBT:

Zoom-in/out capability: Although the MM software system has other usages beyond that of education, this feature is one of its major features and it is not present in any other educational software systems. It allows learners to put together all the learning material on one page or one computer display, enabling them to easily see relationships between elements, as well as the big picture (Goldberg 2004). The right side of the human brain is the more big-picture-oriented, whilst the left is more detail-oriented. The zoom out mode in MM software immediately activates the user's right brain functions, allowing the user to get an overview of what he or she is learning. It also acts as an interface that allows the user to then look into the detail of individual learning components, as he or she shifts from zoom-out to zoom-in mode (Carlson-Pickering 1999a; Sankaran 2009; Eden 2008). The ability to zoom in and out is particularly beneficial for right brain-oriented people who are able, and prefer to, see the big picture first before breaking this down as they zoom in to see individual parts in more detail (Critcher & Ferguson 2010; Morris 2008).

Sicinski (2008) pointed out that MM software systems provide learners with the ability to zoom in and out, and view the information as they wish. Because the learner can quickly and easily switch from a local to a global perspective, and vice versa, to view information from a multitude of zoom-levels and angles, the learner can see all the interconnected pieces interacting with each other in multiple ways. When zooming in, learners have the opportunity to read and examine the information in a linear and sequential manner, allowing the learner to engage his or her linguistic and logical intelligences under Gardner's Multiple Intelligences model (1983) or left brain under Sperry's split brain learning model. (1982) On the other hand, when zooming out in MM programs, learners have the opportunity to view all relevant information together on a single view or page. Presenting information in big pictorial images allows the right brain to activate and helps people to assemble/grasp the information quickly. (Carlson-Pickering 1999a) Frey & Fisher (2008) concur, saying that users learn easier and faster when they can see all the information in one large Mind Map (MM) image.

Furthermore, human beings by nature think, dream and predominantly imagine the world in visual images. As a result, MM, as a large visual image, can help to improve a learner's photographic memory. Chunks of information are difficult to understand because learners can't see these chunks from a global perspective. Many times, learners get lost within the details and fail to see the larger picture. Books or classroom lectures tend to present information in a linear and sequential manner, with very little interlocking between topics, thus making it more difficult to fully comprehend and absorb the material (Sicinski 2008).

From a different prospective, Jobson (2003, as cited in Goldberg 2004) observed that when learners are presented with written material, they go straight to a very linear model of thinking. However when learners are presented with learning materials in an MM format, they allow themselves to use as many senses as they possibly can to process their learning. Sicinski (2008) agrees saying that, "Mind Mapping is one of many tools that are critical for accelerated learning," and suggesting that one should study Gardner's Multiple Intelligences theory to help understand how the process of learning can be accelerated.

Carlson-Pickering (1999b) also agrees with the observation presented above, asserting that the nature and structure of MM allows learners to tap into several of their intelligences simultaneously. Furthermore, she suggests that:

- logical and kinaesthetic intelligence is evoked during the creation and navigation of the MM;
- verbal intelligence is stimulated when written text is involved; and
- visual and spatial intelligence is activated by any color and/or images included. (According to Pitek (1998), color text or images are associated with the right brain activities.)

There is enough evidence to suggest that those multimedia/interactive features that were present in CBT, but absent in MM programs, and vice versa, do play a significant role in stimulating certain learning pathways. In conclusion, therefore, neither CBT nor MM software systems on their own have the ability to provide learners with a truly 'multi-sensory' learning capability.

This paper is limited to the discussion of learning styles and related issues. Other issues surrounding educational software systems like CBT and MM software, such as cost saving, time saving and increased motivation are not discussed in this paper. Ability to distribute educational software system over the web has its own advantages and disadvantages and can be classified as one of the multimedia/interactive features. However, since it has no relationship to learning styles, this feature has been omitted in the discussion of this paper.

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